



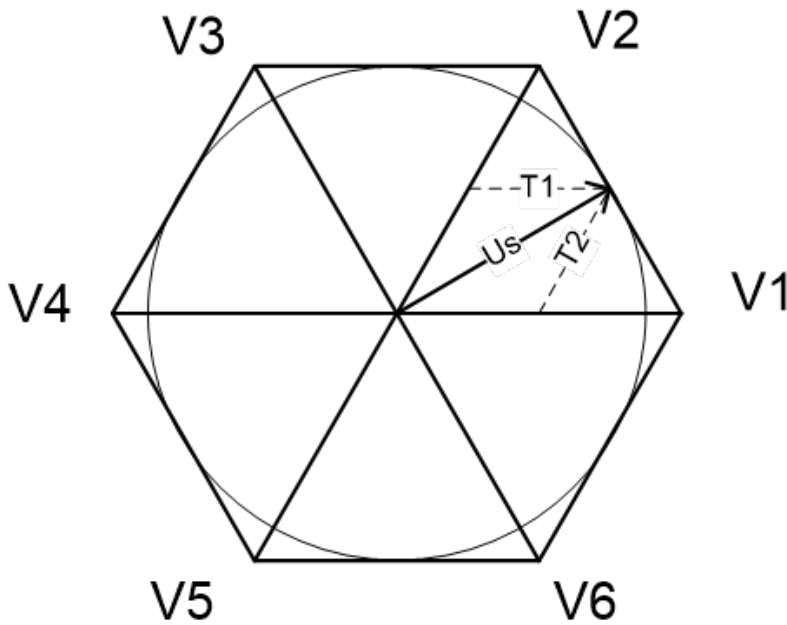
STM32 MC SDK Overmodulation (new in V5.Y)



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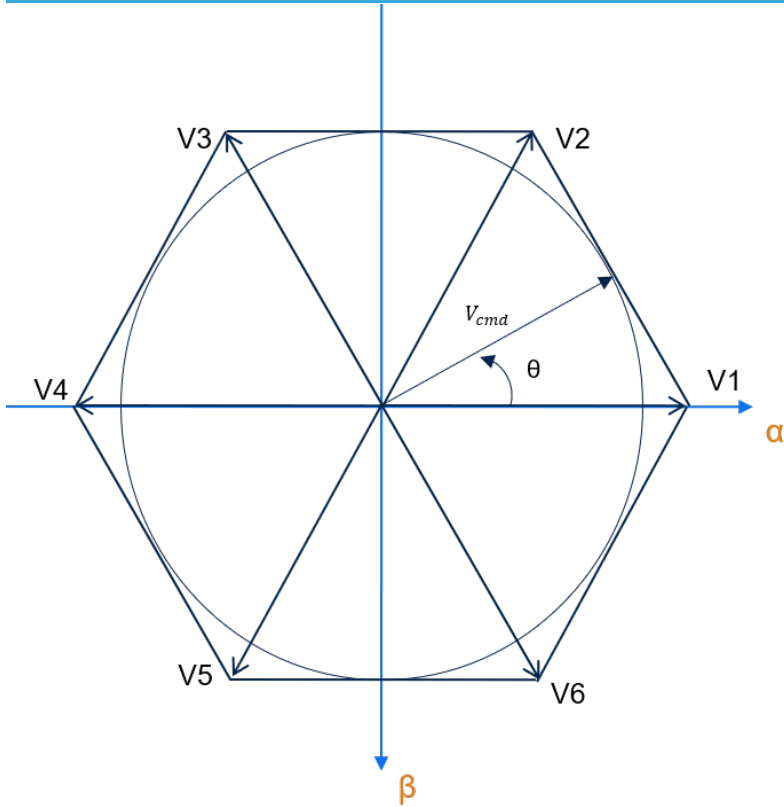
1 Principle of SVPWM



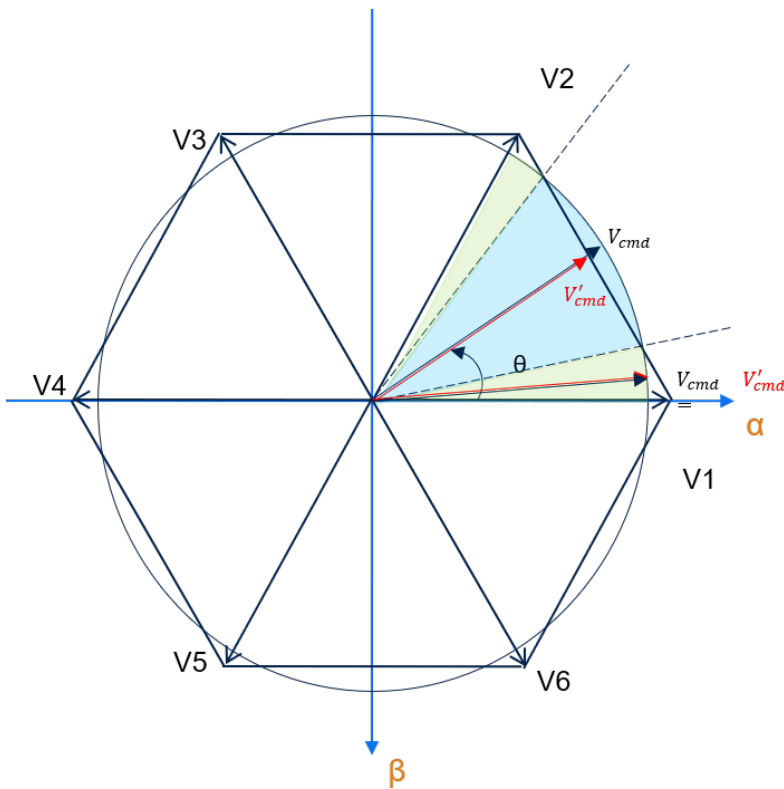
Space vector modulation index is limited to 3/2 but there is a way to extend this limit with the over-modulation. This technique is required when the modulation index, as the length of the reference space vector U_s , exceeds the edges of the hexagon.

1.1 Linear mode

In the linear area, V'_{cmd} can keep both the amplitude and angle of V_{cmd} ,
 then $V'_{cmd} = T'_1 * V_1 + T'_2 * V_2$ with $T'_1 = T_1$ and $T'_2 = T_2$.



1.2 OVM mode 1



There are two cases:

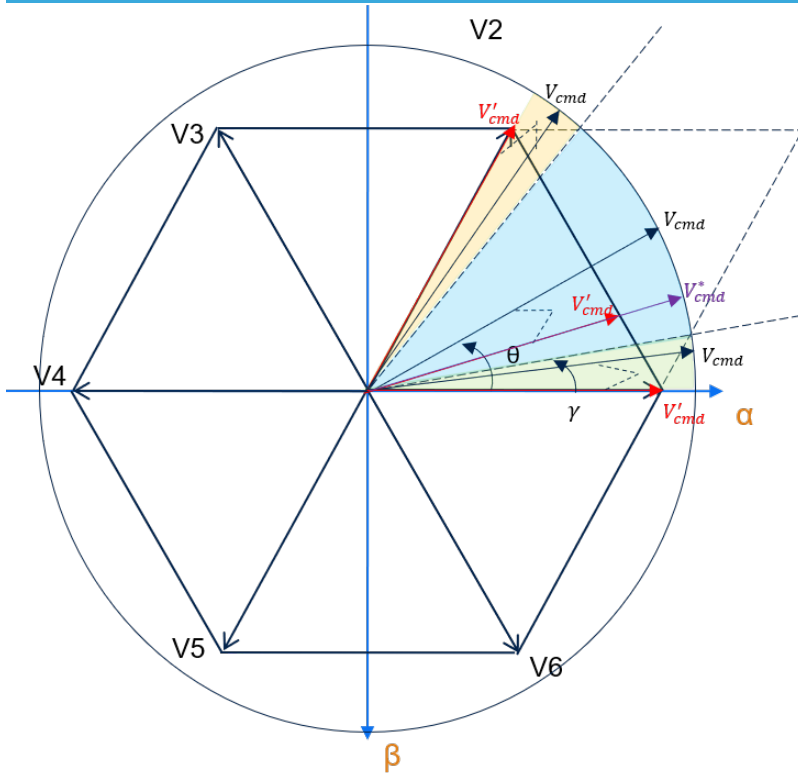
- In the green area: $T_1 + T_2 \leq 1$.

V_{cmd} is unmodified and the timings remain unchanged $T'_1 = T_1$ and $T'_2 = T_2$. In that region V'_{cmd} follows the circle.

- In the blue area: $T_1 + T_2 > 1$.

Then In order to keep V'_{cmd} on the edge of the hexagon and keep the angle, $|V'_{cmd}|$ is shrunk to make $T'_1 + T'_2 = 1$. $V'_{cmd} = T'_1 * V_1 + T'_2 * V_2$ with $T'_1 = T_1 / (T_1 + T_2)$ and $T'_2 = T_2 / (T_1 + T_2)$. In that region V'_{cmd} follows the hexagon edge.

1.3 OVM mode 2



There are three cases:

- In the green area: $T_1 \geq 1.0$.

We only use V1 to generate the V'_{cmd} .

Then $V'_{cmd} = T'_1 * V_1 + T'_2 * V_2$ with $T_1 = 1.0$ and $T_2 = 0$.

- In the yellow area: $T_2 \geq 1.0$.

We only use V2 to generate the V'_{cmd} .

Then $V'_{cmd} = T'_1 * V_1 + T'_2 * V_2$ with $T_1 = 0$ and $T_2 = 1.0$.

- In the blue area: $T_1 < 1.0$ & $T_2 < 1.0$.

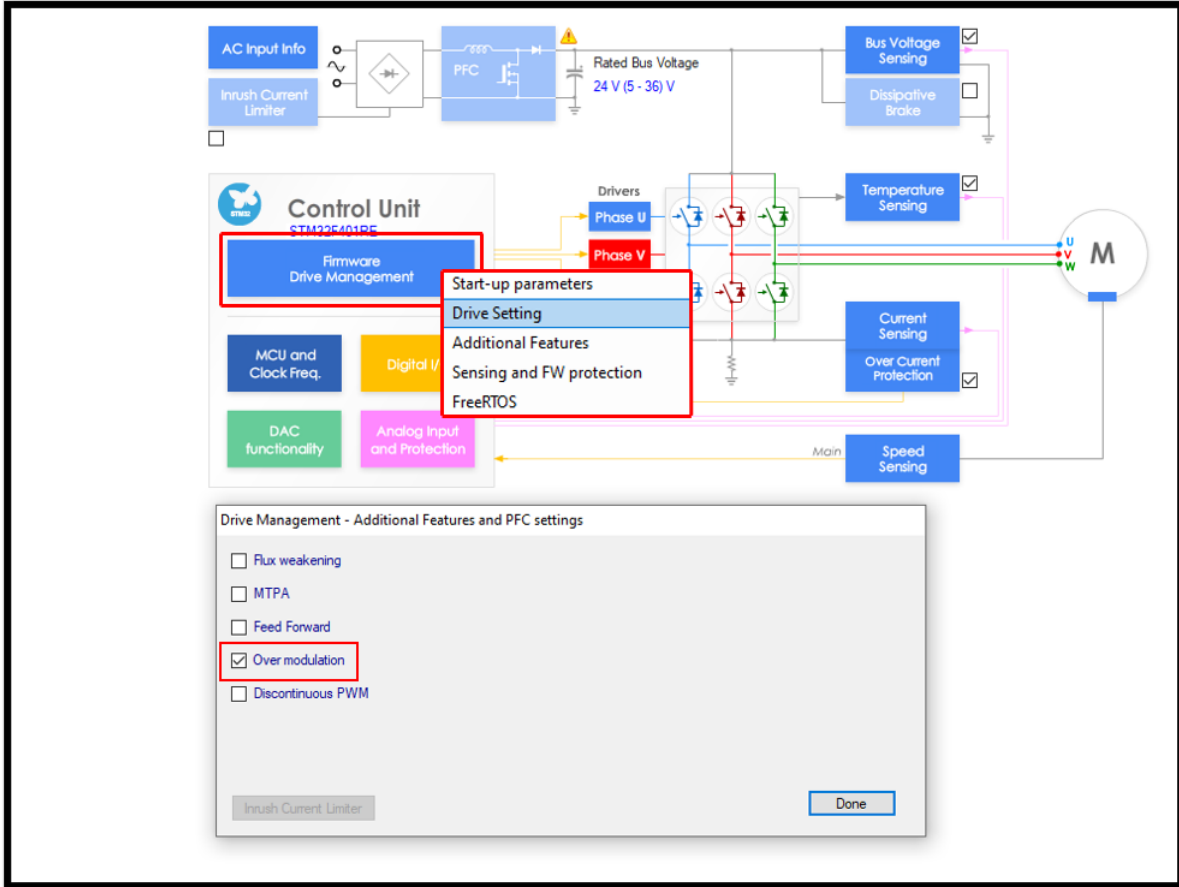
Then $V'_{cmd} = T'_1 * V_1 + T'_2 * V_2$ with $T'_1 = (T_1 / (T_1 + T_2) + 3 / \pi) * (\pi / 6) / (\pi / 6 - \gamma)$ and $T'_2 = 1.0 - T'_1$.

2 Over-modulation timings sum-up

	Linear	OVM Mode 1	OVM Mode 2
T'_1	$T'_1 = T_1$	if $T_1 + T_2 > 1$ $T'_1 = \frac{T_1}{T_1 + T_2}$ else $T'_1 = T_1$	if $T_1 \geq 1$ $T'_1 = 1$ else if $T_2 \geq 1$ $T'_1 = 0$ else $T'_1 = \left(\frac{T_1}{T_1 + T_2} + \frac{3}{\pi} \gamma \right) \frac{\pi/6}{\pi/6 - \gamma}$
T'_2	$T'_2 = T_2$	if $T_1 + T_2 > 1$ $T'_2 = 1 - T'_1$ else $T'_2 = T_2$	if $T_1 \geq 1$ $T'_2 = 0$ else if $T_2 \geq 1$ $T'_2 = 1$ else $T'_2 = 1 - T'_1$



3 Over-modulation activation in STM32 MC SDK V5.Y



4 Over-modulation example

Example: F4 three shunt with Shinano motor at 4000 rpm



- In the middle of this snapshot: the blue curve shows the phase current
- Just below: the pink, yellow and green curves show the PWM channels



The over-modulation increases the total harmonic distortion, but it allows the modulation index to exceed $3/2$.